THE EFFECT OF ASPHALT MULCHES ON THE STABILIZATION OF SOILS AND AGGREGATE MATERIALS AND ON VEGETATIONAL COVER

BY

HAROLD MARION SMITH

B.S., University of Missouri, 1934
M.S., University of Illinois, 1948

R. UNIV. BIBLIOTHEEK LEIDEN

AN ABSTRACT OF A THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN AGRONOMY
IN THE GRADUATE COLLEGE OF THE
UNIVERSITY OF ILLINOIS, 1953

URBANA, ILLINOIS

1953

THE EFFECT OF ASPHALT MULCHES ON THE STABILIZATION OF SOILS AND AGGREGATE MATERIALS AND ON VEGETATIONAL COVER

BY

HAROLD MARION SMITH

B.S., University of Missouri, 1934
M.S., University of Illinois, 1948

AN ABSTRACT OF A THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN AGRONOMY
IN THE GRADUATE COLLEGE OF THE
UNIVERSITY OF ILLINOIS, 1953

URBANA, ILLINOIS

1953

ACKNOWLEDGMENT

The author is indebted to Dr. W. L. Burlison, Professor of Agronomy, Emeritus, and former head of the Department of Agronomy, University of Illinois, for his encouragement and inspiration during the early part of his graduate training; to Dr. M. B. Russell, head of the Department of Agronomy, for his advice and support in carrying this work to completion; to Dr. C. L. Stewart, Professor of Agricultural Economics, for his wise counsel, encouragement, and friendly interest; to Dr. R. S. Stauffer, Associate Professor of Soil Physics, for his understanding attitude and kindness.

He especially wishes to express his appreciation to Dr. G. H. Dungan, Professor of Crop Production, and graduate advisor during the final two years, for his counsel and helpful recommendations during the preparation of the manuscript, and to Dr. J. A. Jackobs, Associate Professor of Crop Production, for suggestions and critical reading of the manuscript.

The author wishes to acknowledge the helpful advice given by the late Dr. R. F. Fuelleman, under whose direction the first two years that this project was conducted, and to Mr. Bruce B. Clark, State Conservationist, Soil Conservation Service, United States Department of Agriculture, for adjusting the service schedule of the author so that the work might be completed at this time.

Special acknowledgment is due the Paris Division of the Illinois Highway Department, the Physical Plant Department of the University of Illinois, cooperating farmers and others in carrying out the applied phase of this research work; to Mr. Rollin J. Smith, Professional Engineer, for making the special asphalts available for the initial phases of this investigation.

THE EFFECT OF ASPHALT MULCHES ON THE STABILIZATION OF SOILS AND AGGREGATE MATERIALS AND ON VEGETATIONAL COVER

Introduction

The need for a suitable mulch to protect new seedings on areas subject to erosion has been recognized for many years. Straw has often been used as a mulch, but straw has several disadvantages. It will often blow and drift and not furnish protection to the critical areas where needed. In dry weather it presents a serious fire hazard. If a layer of straw heavy enough to control erosion is applied, it may smother out the grass seeding.

During the past few years, intermittent attempts have been made to use asphalt as a mulch for holding new seedings in place until such time as the grass has developed a sufficient root system to hold the soil. This investigation was designed to study and evaluate the use of asphalt in stabilizing soils and aggregate materials where an erosion resistant turf is desired.

Materials and Methods

Asphalt occurs in nature as rock asphalt and as a residue from the refining of petroleum known as asphalt cement. Both types must be rendered to the liquid form before they are suitable for use. When asphalt is rendered liquid by thinning with a light oil as kerosene, it is known as "cut-back asphalt." It may be emulsified with water and a suitable emulsifying agent and when so prepared, it is known as "emulsified asphalt" or "asphaltic emulsion."

During the course of this work, one asphalt of the cut-back type and one of the emulsion type have been used. It is necessary to heat the cut-back asphalt to 140-170 degrees F. prior to application while the emulsion form can be applied

at temperatures of 80-100 degrees F.

The two types were first tested in the greenhouse on a mixture of 90 percent sand and gravel and 10 percent silt, on a silt loam, and on a sand. A seed mixture of 10 pounds Alta fescue, 10 pounds Kentucky bluegrass, 5 pounds red top and 5 pounds rye grass was used on the greater part of this experimental work.

The ability of the asphaltic covering to prevent water loss from the soil by evaporation was also tested in the greenhouse.

Tests were made on the Agronomy South Farm during 1950. These tests were designed to compare: (a) no treatment, (b) asphalt treatment, soil not watered prior to spraying, ground not rolled, (c) asphalt treatment, soil rolled and watered prior to spraying, (d) different times of seeding, (e) different rates of seeding and different species of seeds.

To test this material under practical field conditions, repairs were made on broken terrace outlets, gullied highway shoulders, and eroded sloping lawn areas where the establishment of sod was difficult to accomplish.

Experimentally in the greenhouse and on the Agronomy South Farm, the asphalt emulsion was applied with a common three-gallon orchard type sprayer with a built in pressure pump. It was necessary to enlarge the opening in the sprayer nozzle to handle the asphalt which is much heavier than an ordinary water solution.

On work done in cooperation with the Illinois Highway Department, a portable two-wheel asphalt sprayer was used with excellent results. Similiar equipment was used in experiments carried out in cooperation with the Physical Plant of the University of Illinois. In other tests a compressor was attached to a small 3 h.p. gasoline motor. An inlet hose was inserted in a drum of asphalt emulsion and a common garden hose was used as an outlet hose. A common garden hose nozzle suitable for sprinkling lawns was used for the spraying.

In addition to testing the two special asphalts previously

described, tests were made on an asphalt of the RC type used in highway construction.

Studies were made to determine the soil temperature under an asphalt mulch as compared to soil temperatures in an unmulched check plot. Temperature readings were made at one-half inch depths.

Results and Discussion

In the greenhouse, stands of grass which rated "excellent" were obtained on gravel-silt mixtures on plots that had been sprayed with the asphalt emulsion at the rate of .2 gallon per square yard. Excellent stands were also obtained on silt loams. On a pure sand the stand under asphalt was rated "very good". This indicated that asphalt might be used on almost any type of soil material. Under field conditions it was tried on materials varying in texture from silt loam to clay loams and clays with excellent results.

The seedlings actually penetrated a solid covering of asphalt even where no cracks developed. In drying, however, the asphalt usually forms small cracks in a more or less honeycomb pattern. In this case, the seedlings usually come up through the cracks in the asphalt. However, observations indicated that the checking or cracking was not necessary for successful stands of grass. Applications of .6 gallon per square yard did not show any checking or cracking on the surface, yet the seedlings pushed directly through the asphalt.

Studies were made on rates of application of asphalt to test the effect on growth of seedings under varying thicknesses of mulch. Rates of .2, .3, .4, and .6 gallon per square yard were used in special experiments. Rates higher than .6 gallon per square yard were not tried because at that rate the material begins to run together and flow on the surface. The amazing thing about these tests was that growth actually seemed to be better under the heavier than the lighter rates of application. These rate tests were made with the idea that perhaps, as the slope of an area increased the rate of appli-

cation might need to be increased to more effectively control the erosion.

It was not possible to observe any marked difference in the ability of the seedlings of monocotyledons and dicotyledons to push through the layer of asphalt. Separate tests made on corn, oats, rye, red clover, sweet clover, Korean lespedeza, alfalfa, Kentucky bluegrass, rye grass, Alta fescue, and red top, all showed excellent stands coming through the asphalt covering.

Experiments conducted during 1952 showed that a small grain (rye) nurse crop was a definite detriment to the establishment of a stand of grass. Areas without a nurse crop had stands of grass that rated "very good" to "excellent" while those with a rye nurse crop rated "failure". The seeding with the small grain looked good in the early spring but as the season progressed, the dry weather and the competition from the ripening grain, was more than the young plants could endure and the grass gradually disappeared.

The seedings used in this work were mainly a mixture of red top, Alta fescue, Kentucky bluegrass, and rye grass. It will be noted that no legume seed was included. This was done with the idea that on critical areas as waterways, terrace outlets and highway shoulders, a tough sod will be formed much faster by grasses alone with liberal amounts of nitrogen, than by grasses and legumes together without nitrogen except that which would be fixed by the legume. Legumes, in general, do not give the massive, fibrous root system for holding the soil as do the grasses. If legumes are seeded with grasses and liberal amounts of nitrogen added, the grasses will generally smother out the legumes the first year literally wasting the legume seed.

On numerous occasions, it was noted that seedlings emerged as much as two weeks sooner on the plots treated with asphalt than on the check plots. Since this was probably a reflection of moisture and temperature, tests were made to determine the water loss and temperature on treated compared

to untreated plots. Temperatures under the asphalt were from 6.9 to 16.7 degrees F. higher than on the check plots. Variation depended upon the direction of the slope.

At the end of two weeks six untreated plots had lost a total of 4655 grams of water while six treated plots of the same size had lost only 2280 grams. This combination of higher temperature and higher moisture probably accounts for the accelerated germination of seeds under the asphalt covering.

During the growing season of 1950, numerous experiments made throughout the spring, summer and fall comparing sprinkling versus non-sprinkling, showed no advantage for sprinkling the seedbed with water prior to application of the asphalt. Tests made on highway shoulders along U. S. Highway 40 in 1951 and the spring of 1952 showed excellent stands of grass without sprinkling. The reverse was true on seedings made during the fall of 1952. Results in the spring of 1953 showed an "excellent" stand of grass on the sprinkled area and a poor stand on the unsprinkled area. These results were on the plots seeded in the fall of 1952. The need for sprinkling will vary with the season and soil moisture conditions at the time of seeding.

Seedings made during July and early August 1950 were failures on both the treated and untreated plots. This indicated the failure was not the fault of the asphalt but due to weather conditions.

Raking the surface compared to rolling the surface after seeding and prior to application of the asphalt was tried. The results indicated the asphalt tends to cling more tenaciously to the raked surface during periods of intense rainfall. The asphalt does not seem to penetrate or bind the soil on the rolled areas nearly as much as on the raked areas.

A firm, compact, well prepared seedbed is essential prior to seeding and spraying. One repair job on a terrace outlet failed because the fill material was not compacted or properly prepared prior to spraying the asphalt. Clods on the surface will roll during an intense rain and cause a break to develop.

In an experiment in cooperation with the Illinois Highway Department one area was sprayed with an asphalt of the RC type commonly used in building roads. The stand of grass was rated as "failure." This was probably due to the extreme hardness of the asphalt and also to toxic oils such as kerosene.

Both types of asphalt seemed to have certain advantages and disadvantages. While the asphalt emulsion may be sprayed without heating, it was found to have a tendency to "settle out" when stored for six months or more. In the winter, it must be protected from freezing to prevent separation. It is necessary to heat the cut-back to 140-170 degrees F. prior to application. This is not a disadvantage if the proper type of equipment is available. It does not have the disadvantages mentioned for the emulsion.

The asphalt tends to gradually break up and disappear about one year after application. No detrimental effects on the soil have been noticed following the use of these asphalt preparations. Since the asphalt in no way makes up for the lack of plant food in the soil, it is necessary to use liberal applications of complete fertilizer. Applications of 600 pounds per acre of 8-8-8 were used successfully during many of these tests.

At the present time (1953), a 55-gallon drum is the smallest container in which the asphalt material is packaged. The emulsion is shipped from Chicago Illinois and the cut-back from El Dorado, Arkansas. Mr. Rollin J. Smith of 2625 West 50th Street, Kansas City, Kansas, is the selling agent. Prices quoted during 1952 were 20-22 cents per gallon in 55-gallon drums and 12 cents per gallon in tank cars.

Rates of application will vary between .2 and .4 gallon per square yard. At .3 gallon per square yard the cost would be about 7 cents per square yard at the drum rate or 4 cents at the tank car rate. This compares favorably with the cost of a straw mulch. Asphalt opens a new field for the landscape architect to do custom spraying in lawn establishment.

Over 300 letters have been received from 38 states and

five foreign countries inquiring about the use of asphalt mulches in erosion control. This fact indicates the tremendous need for a better means of establishing sod on areas subject to erosion.

CONCLUSIONS

As a result of testing special asphalts in the greenhouse, on the Agronomy South Farm, and under practical field conditions the following trends are indicated:

1. The use of special asphalt emulsion or cut-back asphalt has a place in establishing grass seedings on such areas as lawns, parks, pipe lines, along highways and railroads, airports, waterways and terrace outlets.

2. Satisfactory growth of grasses and legumes can be obtained on soil materials varying from sands to clays after having been sprayed with asphalt.

3. A firm compact seedbed should be prepared with liberal applications of a complete fertilizer such as 8-8-8. The grass is seeded and lightly covered and then the asphalt is sprayed on. Sprinkling the asphalt is not satisfactory. It must be applied as a spray. The need for sprinkling the soil with water prior to application of the asphalt depends on the particular seasonal conditions and the supply of soil moisture.

4. Seeding may be made earlier in the spring and later in the fall when the asphalt is used, than when seeding without asphalt. The asphalt covering prevents evaporation and increases soil temperature from 7 to 15 degrees F. Seedings made during mid-summer are not satisfactory.

5. Rates of application will vary from .2 to .4 gallon per square yard depending upon the slope of the area to be treated. Three-tenths gallon per square yard gives an even covering.

6. A variety of equipment is available for applying the asphalt, varying from three-gallon hand sprayers to large units of several hundred gallons capacity.

7. Cost of the asphalt is from 4 cents to 7 cents per square yard at a .3 gallon per square yard rate.

8. If proper equipment is available for heating, the cut-back material seems to have certain advantages over the emulsified type. Asphalts commonly used in road construction did not permit grass to grow through them.

VITA

Harold Marion Smith was born on July 16, 1911, on a farm near Henley, Missouri. His early education was received in the public schools at Henley, Missouri. He attended high school in Jefferson City, Missouri. He entered the University of Missouri and received the degree of Bachelor of Science in Agriculture in 1934.

In August 1934, he began working for the Soil Conservation Service. Positions held with this organization since then were Soil Surveyor in North Missouri and Southern Iowa 1934-1935; Project Soil Scientist at Fulton, Missouri, 1935-1937; Project Soil Scientist at Freeport, Illinois, 1937-1939; Area Soil Scientist in charge of South one-half of Missouri, 1939-1940; and Soil Scientist in charge of Surveys, State of Missouri, 1940-1942.

He entered the Army in July 1942. While in the Army, he studied soil stabilization at Harvard University and attended the Intelligence School at Harrisburg, Pennsylvania. He was discharged from the Army in August of 1946, with the rank of Captain. After returning from the Army in 1946, he was transferred to Urbana, Illinois, as Assistant State Soil Scientist with the Soil Conservation Service where he is currently working as Survey Supervisor.

While on leave from the Soil Conservation Service in 1937-1938, he did graduate work in soils at the University of Missouri. He entered the Graduate College of the University of Illinois, on a part-time basis in 1947, and received the degree of Master of Science in Agronomy in 1948.

He is a member of Sigma Xi, Alpha Zeta, Alpha Gamma Rho, Gamma Sigma Delta, Mohammed Temple, the American Society of Agronomy and the Soil Science Society of America.

He is the author of three popular articles published during the past year. He is co-author of two technical publications of the Illinois State Water Survey.